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## HYBRID COMPRESSOR AND CONTROL DEVICE

## CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and incorporates herein by reference Japanese Patent Application No. 2002-203758 filed on July 12, 2002.

~~FIELD OF THE INVENTION~~ BACKGROUND OF THE INVENTION

[0002] The present invention relates to a hybrid compressor that is used mainly for a vehicular air-conditioning device and driven selectively by an engine or an electric motor, and its control device.

~~BACKGROUND OF THE INVENTION~~

[0003] In a typical vehicular air-conditioning device, cooling cannot be executed ~~due to no driving of a compressor while an engine of a vehicle stops~~ when the engine driving the vehicle is stopped. Recently, there are ~~an idling stop vehicle that stops its engine while temporary stop in the traveling and a vehicle that stops its engine even during the traveling depending on a condition~~ vehicles have been developed that stop the engine when the vehicle is temporarily stopped. Further, in another new type of vehicle, the engine may be stopped even while the vehicle is traveling, depending on conditions. In these vehicles, a hybrid compressor ~~that is driven by an engine while the engine is turned on and by an electric motor while the engine is turned off~~ is used for obtaining comfortable cooling performance is used for comfortably cooling the passenger cabin. The hybrid

compressor is driven by the engine while the engine is running  
by an electric motor when the engine is stopped.

[0004] One ~~of hybrid compressors~~hybrid compressor and its controlling method ~~are~~is disclosed in JP-A-2000-110734. This hybrid compressor is furnished with a compression mechanism having a rotating shaft, an electric motor having an output shaft connected with the rotating shaft, and an electromagnetic clutch connected with the output shaft. An engine is connected with the output shaft through the electromagnetic clutch. When the engine is in an operating state and the electromagnetic clutch is turned on, the driving force of the engine is transmitted through the output shaft to the rotating shaft so that the compression mechanism can be driven. By contrast, when the engine is ~~in a stopping state~~stopped, the electromagnetic clutch is turned off, and the output shaft and the rotating shaft are ~~thereby separated~~disconnected from the engine, the electric motor drives the compression mechanism using ~~an~~the electric power of a battery.

[0005] Furthermore, in the above hybrid compressor, a swash-plate type externally variable displacement compressor is adopted. In this compressor, a piston is driven by ~~a~~the rotation of a swash plate, and a displacement adjusting mechanism is externally adjusted, so that a certain displacement can be obtained ~~through~~by varying of ~~an~~the inclination angle of the swash plate. In order to constantly ~~optimizing~~optimize the cooling performance in a refrigerating ~~eye~~circuit, the inclination angle of the swash plate is adjusted based on ~~a~~the cooling load so that the ~~discharging~~discharge displacement can be controlled.

[0006] The applicant of the present invention discloses, in JP-A-H10-291415, a method for enabling a motor of a hybrid compressor to be ~~downsized~~ reduced in size and ~~fitly~~ mounted on a vehicle. In this hybrid compressor, ~~a~~ the load of the motor is set to zero when the motor is turned on. The load of the motor is then increased after ~~a revolution~~ rotation of the motor becomes stable.

[0007] However, in the above case, it takes an interval to return to the required displacement after the displacement is once shifted to zero. In particular, when ~~required~~ heat capacity is low and the target cooling temperature ~~capacity~~ is low, it takes a longer interval to return to the required displacement. This ~~results in inhibiting comfort of~~ inhibits the air-conditioning and reduces passenger comfort for the interval.

#### SUMMARY OF THE INVENTION

[0008] It is an object of the present invention to provide a hybrid compressor that ~~enables displacement is rapidly recovered when the compressor starts being driven by an electric motor~~ rapidly produces the required displacement when an electric motor starts to drive the compressor.

[0009] To achieve the above object, a hybrid compressor is controlled as ~~follow~~ follows. When a hybrid compressor starts being driven by a motor, the hybrid compressor is operated by controlling a control device for operating at a first control value to ~~thereby~~ trigger a swash plate of the hybrid compressor to be rapidly inclined. The hybrid compressor is thereafter operated by controlling the control device for operating at a second control value ~~than which the first control value is~~

~~greater~~, which is less than the first control value. This structure enables the displacement of the hybrid compressor to ~~be rapidly recovered~~recover.

[0010] In one aspect of the present invention, a control device includes a capacity control valve of the hybrid compressor. ~~Here, the~~The capacity control valve is operated at a first or second electric current applied to the capacity control valve as the first or second control value ~~in the above, respectively~~. The first electric current is greater than the second electric current ~~that is obtained from a~~, which is obtained from the status of ~~a the~~ refrigerating electric circuit.

[0011] In another aspect of the present invention, a control device includes the electric motor. ~~Here, the~~The electric motor is operated at a first or second revolution number as the first or second control value, respectively. The first revolution number is greater than the second revolution number.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

[0013] FIG. 1 is a schematic diagram showing overall structure of a vehicular air-conditioning system using a hybrid compressor according to an embodiment of the present invention;

[0014] FIG. 2 is a sectional view of a swash-plate type externally variable displacement compressor according to the embodiment of FIG.1;

[0015] FIG. 3 is a flow diagram ~~explaining processing~~  
~~for~~ illustrating a main control process of an ECU used in the  
vehicular air-conditioning system;

[0016] FIG. 4 is a graph showing relationship between  
refrigerant pressure of higher pressure portion and either of an  
initial control electric current of a control valve or initial  
control revolution number of a motor;

[0017] FIG. 5 is a flow diagram explaining compressor  
controlling in the flow chart of FIG. 3;

[0018] FIG. 6 is a flow diagram explaining processing of  
controlling in motor driving according to ~~a~~ the first  
embodiment;

[0019] FIG. 7 is a time chart showing operational contents in  
the motor driving according to the first embodiment;

[0020] FIG. 8 is a flow diagram explaining processing of  
controlling in motor driving according to a second embodiment;  
and

[0021] FIG. 9 is a time chart showing operational contents in  
the motor driving according to the second embodiment;

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

{First embodiment}

[0022] FIG. 1 shows the overall structure of a vehicular air-  
conditioning system using a hybrid compressor according to an  
embodiment of the present invention. This embodiment is directed  
to a vehicle such a truck that conveys baggage. In this truck,  
in order to prevent an engine from continuing to be operating  
during the loading or unloading of baggage, the engine is turned

off while the truck stops. When the cooling capacity runs short, the engine is turned on.

[0023] In FIG. 1, an engine 1 is a driving source for moving the vehicle~~traveling~~. An output shaft of the engine 1 is connected with a driving pulley 2 that is rotated in conjunction with the driving of the engine 1. The driving pulley 2 and a known electromagnetic clutch 3~~that is for interrupting force, which interrupts the driving force~~, are belted-connected with a transmission belt 7~~that is for transmitting force~~. When the electromagnetic clutch 3 is engaged, the engine 1 is~~to be~~ connected with a compressor 4~~that, which~~ is a part of a refrigerating cycle-circuit 5, and the compressor 4 is driven by the engine 1.

[0024] The compressor 4 can be also driven by a built-in electric motor 6 (direct current (DC) motor). The electric motor 6 is driven by being power supplied ~~with a power from~~by an in-vehicle battery (not shown). The compressor 4 is driven selectively by either ~~of~~ the engine 1 or the electric motor 6.

[0025] ~~Namely, in~~In this embodiment, when the electric motor 6 drives the compressor 4 during a ~~stopping~~stopped state of the engine 1, coordination between the engine 1 and the compressor 4 is interrupted by disengaging the electromagnetic clutch 3. The compressor 4 is then driven by ~~driving~~ the motor 6. A one-way clutch can be also used ~~as an electromagnetic clutchless type~~ for switching the driving methods.

[0026] The refrigerating ~~cycle~~circuit 5 will be briefly explained below. FIG. 2 shows a sectional view of a swash-plate type externally variable displacement compressor according to ~~the~~this embodiment. In this compressor 4, a compression

mechanism such as a piston 43 is driven by rotation of a swash plate 41. ~~An~~ The internal pressure within a swash-plate chamber 42 is adjusted ~~for~~ to set the inclination angle of the swash plate 41. Thus, the inclination angle can ~~to be~~ varied by an electromagnetic pressure capacity control valve (capacity control valve) 4a that is externally controlled (shown in FIG. 1). ~~A discharging~~ The discharge displacement is ~~thereby~~ varied based on the inclination angle of the swash plate 41.

[0027] A suction port 44 is fluidly connected with an outlet of an ~~after-mentioned~~ evaporator 14, while a discharge port 45 is fluidly connected with an inlet of an ~~after-mentioned~~ a condenser 11. A shaft 61 is ~~a~~ the rotating shaft of the compressor 4 and also an output shaft of the electric motor 6. The electric motor 6 includes a stator 62 and a rotor 63 ~~that~~ , which is rotated with the stator 62. The shaft 61 is connected with the electromagnetic clutch 3 at its leftmost end ~~of~~ in FIG. 2.

[0028] The refrigerating ~~cycle~~ circuit 5 includes, as shown in FIG. 1, in addition to the compressor 4, known devices as follows: the condenser 11 ~~where a~~ , in which refrigerant compressed by the compressor 4 is condensed and liquefied; a receiver 12 ~~where the~~ , in which condensed and liquefied refrigerant is divided into a liquid phase and a gas phase; an expansion valve 13 ~~where~~ , at which the liquid phase of the refrigerant is expanded and decompressed; and the evaporator 14 ~~where~~ , at which the expanded refrigerant is evaporated.

[0029] The evaporator 14 is a heat exchanger for cooling of a vehicular air-conditioning system 100 through which a cabin (or ~~vehicle~~ passenger compartment) of the vehicle is air-conditioned. The vehicular air-conditioning system 100, ~~as is~~

~~commonly known,~~ includes an air-conditioning case 101 ~~that is,~~ which provides an air passage to the cabin and which contains an air fan (blower) 102, the evaporator 14, a heater core 103, an air mix door 104, and the like. The heater core 103 is downstream from the evaporator 14, and ~~a~~ the heat source of the core 103 is engine cooling water. The air mix door 104 is for adjusting the temperature of ~~an air-conditioning blow~~ the air-conditioned air.

[0030] The electromagnetic clutch 3, the compressor 4, and the electric motor 6 are controlled by an electronic control unit (ECU) 15 as a control device. The ECU 15 is supplied with ~~a~~ power from an in-vehicle battery (not shown) when an ignition switch (IG SW) that enables ~~the vehicle traveling~~ travel is turned on.

[0031] The ECU 15 is connected to various components with output terminals as follows: a clutch control circuit 17; a motor drive circuit 18; and a displacement control circuit 19. The electromagnetic clutch 3 is controlled through the clutch control circuit 17 by the ECU 15. The electric motor 6 is controlled through the motor drive circuit 18 by the ECU 15. The capacity control valve 4a of the compressor 4 is controlled through the displacement control circuit 19 by the ECU 15.

[0032] The ECU 15 is connected to various components with input terminals as follows: an outside air temperature sensor 20 for detecting air temperature outside the vehicle; an inside air temperature sensor 21 for detecting air temperature inside the cabin; an insolation sensor 22 for detecting an amount of ~~the~~ insolation incident inside the cabin; and a temperature adjuster 23 for setting a target air temperature inside the cabin. The

ECU 15 is furthermore connected with a vehicle speed sensor 24 for detecting ~~a~~the vehicle speed, and an air-conditioning switch (SW) 25 for enabling automatic ~~controlling~~control of the vehicular air-conditioning system 100 based on a signal from the temperature adjuster 23.

[0033] Furthermore, the ECU 15 is connected with other components with input terminals as follows: a pressure sensor 26 for detecting ~~a~~the refrigerant pressure in a higher pressure portion of the refrigerating ~~cycle~~circuit 5; a revolution number sensor 27 for detecting ~~a revolution number~~the number of revolutions of the electric motor 6; an electric current sensor 28 for detecting ~~an~~the electric current for driving the electric motor 6; and a temperature sensor 29 for detecting the temperature of air (at an outlet of the evaporator 14) just after the air passes through the evaporator 14. In this embodiment, only when the air-conditioning switch 25 is turned ~~on, then~~on can the compressor 4 and the blower 102 ~~can~~ be automatically controlled.

[0034] ~~Main~~The main control of the air conditioning system 100 by the ECU 15 will be explained with reference to FIG. 3.

[0035] At Step 1, stored values are initialized when automatic control of the air-conditioning system 100 is started.

[0036] At Step 2, a target temperature that is set using the temperature adjuster 23 by a ~~crew~~passenger is read and other values such as temperatures are also read from the outside air temperature sensor 20, the inside air temperature sensor 21, the insolation sensor 22, the temperature sensor 29, and other water temperature sensors (not shown). These values are then properly corrected.

[0037] At Step 3, ~~temperature~~ an air output temperature (TAO) that is ~~necessary blow temperature~~ required for achieving the target temperature based on the temperature condition obtained at Step 2 is computed from a formula.

[0038] At Step 4, a motor ~~controller's~~ controller voltage for driving the blower 102 is controlled based on a relationship between the necessary ~~blow~~ air output temperature TAO and a blower air amount (or blower voltage).

[0039] At Step 5, an opening degree of the air mix door 104 for achieving the necessary ~~blow~~ air output temperature TAO is determined based on the necessary ~~blow~~ air output temperature TAO and the temperature condition obtained at Step 2, in accordance with a formula, and controlled through a servo motor (not shown).

[0040] At Step 6, one of blowing modes ~~ef~~ including a face mode, a foot mode, and a bi-level mode is determined and controlled through a servo motor (not shown). It is determined from the necessary ~~blow temperature~~ air output TAO based on blowing mode pattern data indicating a relationship between the necessary ~~blow temperature~~ air output TAO and the blowing mode of the air stream into the cabin.

[0041] At Step 7, the electromagnetic clutch 3, the electric motor 6, the capacity control valve 4a, and the like are controlled ~~in after mentioned processing of compressor~~ controlling in a compressor control process described below. The flow chart from Step 1 to Step 7 is repeated at approximately 0.25 ~~second~~ seconds per ~~eye~~ elec circuit.

[0042] In the next place, ~~the processing of the compressor~~ controlling a compressor control process will be explained with

reference to FIG. 5. This ~~processing process~~ can be executed while the ignition switch 16 is turned on.

[0043] At Step 11, it is determined whether the air-conditioning switch 25 is tuned on. When the switch 25 is turned off, ~~the vehicular~~ it is unnecessary to operate the air-conditioning system 100 ~~is unnecessary to be operated for air conditioning the cabin and Step 12 is performed.~~ ~~The processing thereby proceeds to Step 12.~~ Here, the electric motor 6 is turned off and the electromagnetic clutch 3 is disengaged. The compressor 4 is thereby turned off. When the switch 25 is turned on, ~~the processing proceeds to Step 13~~ is performed.

[0044] At Step 13, it is determined whether a ~~the~~ vehicle speed detected through the vehicle speed sensor 24 is zero. When the speed is determined to be not zero (~~namely when~~ the vehicle is traveling), ~~the processing proceeds to Step 14~~ is performed.

[0045] At Step 14, capacity control for the compressor 4 is executed using the capacity control valve 4a so that ~~an the~~ air temperature detected through the temperature sensor 29 can reach the target temperature. ~~Cooling~~ The cooling load that is necessary for achieving the target temperature decreases with ~~increasing~~ an increase in the target air temperature. The displacement of the compressor 4 decreases with ~~decreasing a~~ decrease in the cooling load. This ~~results in enabling load~~ decreases the load on the engine 1 ~~to be decreased.~~ Thus, the capacity control is executed before the compressor 4 is driven by the engine 1.

[0046] At Step 15, under a condition controlled at Step 14, the electromagnetic clutch 3 is engaged, so that the compressor 4 is driven by the engine 1.

[0047] By contrast, when the vehicle speed is determined to be zero, ~~the processing proceeds to Step 16~~ is performed.

[0048] At Step 16, it is determined whether the cooling load is greater than a preset value (~~namely whether rapid cooling down~~ is necessary). The preset value is positioned between the maximum and the minimum of the selectable cooling capacity of the compressor 4. It is simultaneously determined whether a refrigerant circulating amount is greater than a preset value. For instance, the outside air temperature is extremely high in summer, e.g., more than 30 °C, and the inside air temperature is also high, e.g., more than 30 °C. In this case, the cooling load ~~is~~ will be greater than the preset value.

[0049] In the compressor 4 of ~~the~~ this embodiment, the cooling load of the compressor 4 is indirectly estimated by detecting the outside and inside air ~~temperatures, or~~ temperatures or the applied electric current (duty) to of the control valves. When the cooling load of the cabin is greater than the preset value, ~~the processing proceeds to Steps 14 and 15~~ are performed. The compressor 4 is thereby driven by the engine 1.

[0050] When the cooling load is not greater than the preset value, ~~the processing proceeds to Step 17~~ is performed.

[0051] At Step 17, the engine 1 is turned off and the electromagnetic clutch is disengaged. This situation ~~is supposed~~ occurs when the truck arrives at a destination and temporarily stops for a ~~certain~~ loading or unloading ~~work~~ or when the truck waits at stop lights. Since the cooling load is not greater than the preset value and there is no need for driving the engine 1, the engine 1 is turned off while the ignition switch 16 is tuned on.

[0052] Here, during the ~~certain~~ loading or unloading work, the engine 1 is turned off, so that ~~no exhaust gas leads to no pollution of~~ does not pollute the atmosphere.

[0053] However, when the engine 1 is turned off and the compressor 4 is thereby turned off, the refrigerant does not circulate within the refrigerating ~~eyele-5~~ circuit 5 and the cooling capacity of the vehicular air-conditioning system 100 becomes zero. ~~The air~~ Air-conditioning of the cabin thus cannot be executed. When the cooling load is not greater than the preset value, the compressor 4 is consequently driven ~~through~~ by activating the electric motor 6.

[0054] ~~Namely, when~~ When the cooling load is not greater than the preset value, the necessary capacity of the compressor 4 is less than the preset value and ~~a~~ the circulating amount of the refrigerant is small. As a result, the driving force for the compressor 4 is small, so that the compressor 4 can be driven by the electric motor 6.

[0055] By contrast, when the cooling load is greater than the preset value, the necessary capacity of the compressor 4 is not less than the preset value and the circulating amount of the refrigerant is not small. As a result, the driving force for the compressor 4 is large, so that the compressor is driven by the engine 1 even while the vehicle ~~stops~~ is stopped.

[0056] Thus, even a compact electric motor 6 can drive the compressor 4. ~~This leads to enhancing mountability~~ This improves the mounting flexibility of the electric motor 6. Furthermore, an externally variable displacement type compressor is ~~adopted~~ chosen for the compressor 4. When the cooling load is not greater than the preset value, the electric motor 6 drives the

compressor 4. In comparison with ~~adopting a fixed displacement type compressor~~, the electric motor 6 needs ~~even smaller driving force for the compressor 4 to produce a smaller force when driving a variable displacement type compressor~~. Consequently, ~~a the size of the electric motor 6 when the a variable displacement type is adopted compressor is employed is smaller than that when the a fixed displacement type is adopted compressor is used.~~

[0057] At Step 18, low capacity control of the compressor is executed before the electric motor 6 drives the compressor 4. Here, the displacement is forcibly reduced to a minimum ~~settable~~ level (low capacity state) by controlling the capacity control valve 4a, and then the electric motor 6 is activated. The capacity of the compressor 4 ~~thereby thus~~ becomes small, so that the driving force for the compressor 4 becomes smaller in comparison with a case where the capacity of the compressor 4 is large.

[0058] Thus, the capacity of the compressor 4 is decreased at Step 18. Therefore, a large electric motor having large driving force is not required to drive the compressor 4 at Step 19.~~At Step 19, the compressor 4 is driven by the electric motor 6. Here, the electric motor 6 does not need to be a large size having large driving force by virtue of the above low capacity control at Step 18. Furthermore, This leads to furthermore enhancing downsizing a the size of the electric motor 6 can be reduced and thereby mountability the mounting flexibility of the electric motor 6 is improved.~~ Although it is not shown, ~~this the~~ low capacity state under the driving force of the electric motor 6 continues ~~till until~~ the engine 1 restarts. In the low

capacity state, ~~a revolution number~~ the number of revolutions of the electric motor 6 remains constant.

[0059] Although the refrigerating ~~cycle~~ circuit 5 cannot sufficiently ~~exert~~ provide the cooling capacity necessary for cooling the cabin, cooling can be continued at some degree. For instance, while the truck stops for the loading/unloading work, a temperature increase in the cabin is restricted can be limited. This results in relieving discomfort of the ~~crew posterior~~ passengers after the loading/unloading work.

[0060] At Step 20, it is determined whether elapsed time of driving of the electric motor 6 is longer than a preset time T (e.g., two minutes). When the elapsed time is longer than the preset time T, ~~the processing proceeds to Step 21~~ is performed.

[0061] At Step 21, the electric motor 6 is turned off ~~for preventing~~ to prevent the battery from running out. Alternatively ~~Here~~, the electric motor 6 can be turned off by ~~according to a result of detecting the~~ voltage or capacity of the battery instead of determining the elapsed time of driving.

[0062] Incidentally, there may be a case where the engine 1 ~~is~~ can be naturally turned on for ~~traveling of moving~~ the truck even while the compressor 4 is driven by the electric motor 6. However, if the vehicle remains ~~stopping~~ stopped (being at speed of zero) (Step 13: YES) after the engine 1 is turned on, the engine 1 may be ~~is~~ shortly turned off at Step 17). Therefore, to solve this problem, the following process is additionally designed. That is, once the ignition switch 16 is turned on, the engine 1 is not turned off at Step S17 ~~continues to be turned on~~ for a certain period even when the vehicle remains ~~stopping~~ stopped (Step 13: YES).

[0063] At Step 19, ~~processing for motor driving~~driving of the motor is executed. The ~~processing process~~ will be explained with reference to ~~FIGs~~FIGS. 6 and 7. FIG. 6 shows a flow chart ~~of processing~~for controlling ~~in the~~ motor driving according to a first embodiment of the present invention, while FIG. 7 shows a time chart ~~showing operational contents in~~illustrating operation of the motor driving.

[0064] At Step 31 in FIG. 6, it is determined whether the electric motor 6 is turned off. When the electric motor 6 is determined to be turned off, ~~the processing proceeds to Step 32~~is performed.

[0065] At Step 32, an initial control electric current SS of the capacity control valve 4a is determined based on the relationship, shown in FIG. 4, ~~with~~based on the refrigerant pressure of the higher pressure portion of the refrigerating ~~cycle~~circuit 5. The initial control electric current SS is greater than a control electric current S~~that~~, which is obtained from a state of the refrigerating ~~cycle~~circuit 5.

[0066] In FIG. 4, the relationship between refrigerant pressure of the higher pressure portion and either of the initial control electric current SS or an initial control revolution number SR of the electric motor 6 is shown. The initial control electric current SS and the initial control revolution number SR ~~are~~increasing with increasing increase according to an increase in the refrigerant pressure of the higher pressure portion.

[0067] At Step 33, electric current is applied to the electric motor 6 for driving the electric motor 6 at a preset number of revolutions~~revolution number~~ R.

[0068] At Step 34, it is determined whether the preset ~~revolution number~~number of revolutions R is reached. When the preset ~~revolution number~~number of revolutions R is determined to be reached, ~~the processing proceeds to Step 35~~ is performed.

[0069] At Step 35, the initial control electric current SS determined at Step 32 is applied to the capacity control valve 4a, as shown in FIG. 7. This ~~triggers~~ causes the swash plate 41 to be rapidly inclined.

[0070] At Step 36, it is determined whether a preset time T1 elapses. When the preset time T1 has elapsed, ~~the processing proceeds to Step 37~~ is performed.

[0071] At Step 37, the electric current of the capacity control valve 4a is converged, at a preset time T2, to the control electric current S that is obtained from the state of the refrigerating ~~cycle~~ circuit 5.

[0072] At Step 38, the electric current is controlled to remain at the control electric current S. Hereafter, when the electric motor 6 is determined to be ~~not turned off~~ on at Step 31, ~~the processing proceeds to Step 38~~ is performed, where the electric current of the capacity control valve 4a is repeatedly controlled to remain at the control electric current S.

[0073] Features of this embodiment will be described. In the swash-plate type externally variable displacement compressor of this embodiment, once the displacement starts ~~being recovered to~~ recover by virtue of inclination of the swash plate, force is apt to be applied for the displacement to increase. This tendency is utilized in this embodiment. The initial control electric current SS is greater than a control electric current S that is obtained from a state of the refrigerating ~~cycle~~

5circuit 5. The initial control electric current SS is applied as a trigger for inclination of the swash plate. When the compressor 4 starts being driven by the electric motor 6, the displacement of the compressor 4 can be thereby rapidly recovered.

[0074] Furthermore, the pressure sensor 26 is provided for detecting the refrigerant pressure in the higher pressure portion of the refrigerating ~~eyele-5~~circuit 5. According to the refrigerant pressure in the higher pressure portion of the circuit 5, the initial control electric current SS is varied. The initial control electric current SS is thereby set based on the cooling load of the refrigerating ~~eyele-5~~circuit 5.

[0075] After the compressor 4 starts being driven by the electric motor 6, the initial control electric current SS continues to be used as a target only for the preset time T1. If the swash plate starts being inclined and the initial control electric current SS still continues to be used at the target more than the preset time T1, excessive cooling or wasteful power consumption may occur. The preset time T1 is suitable just for triggering the swash plate to start being inclined.

[0076] As another aspect, the revolution number sensor 27 is provided for detecting the ~~revolution-number~~ of revolutions of the electric motor 6. After the compressor 4 starts being driven by the electric motor 6, a decrease  $\Delta A$  from a preset revolution number R is detected, as shown in FIG. 7. By detecting the decrease  $\Delta A$ , the electric current of the capacity control valve 4a can start to converge from the initial control electric current SS to the control electric current S. The decrease of the ~~revolution-number~~ of revolutions of the motor 6 means that

the swash plate 41 ~~starts being~~has started to be inclined. This structure can also restrict ~~the~~-excessive cooling or wasteful power consumption.

[0077] As another aspect, the electric current sensor 28 is provided for detecting the electric current for driving the electric motor 6. After the compressor 4 starts being driven by the electric motor 6, a decrease  $\Delta B$  from a required value is detected as shown in FIG. 7. By detecting the decrease  $\Delta B$ , the electric current of the capacity control valve 4a can start to converge from the initial control electric current SS to the control electric current S. The decrease of the electric current of the motor 6 also means that the swash plate 41 ~~starts being~~has started to be inclined. This structure can also restrict ~~the~~-excessive cooling or wasteful power consumption.

[0078] As yet another aspect, the temperature sensor 29 is provided for detecting the temperature of air (at the outlet of the evaporator 14) just after the air passes through the evaporator 14. After the compressor 4 starts being driven by the electric motor 6, a shifting point C at which the air temperature that has been increasing starts to decrease is detected as shown in FIG. 7. By detecting the shifting point C, the electric current of the capacity control valve 4a can start to converge from the initial control electric current SS to the control electric current S. Since the displacement of the compressor 4 is recovered, the increasing air temperature starts to again decrease and the shifting point C is detected. This structure can also restrict ~~the~~-excessive cooling or wasteful power consumption.

[0079] The electric current of the capacity control valve 4a converges from the initial control electric current SS to the control electric current S at the preset time T2. This enables a gradual shift to usual control, so that a worsening of cooling feeling or discomfort is prevented. Furthermore, providing the above control device in the compressor 4 enables ~~adopting the use of a~~ swash-plate type externally variable displacement compressor that, which rapidly recovers displacement when the compressor 4 starts being driven by the motor 6.

{Second embodiment}

[0080] A second embodiment will be explained with reference to ~~FIGs~~ FIGS. 8 and 9. The second embodiment is different from the first embodiment only ~~regarding in the motor controlling control~~ of the ECU 15.

[0081] At Step 41 in FIG. 8, it is determined whether the electric motor 6 is turned off. When the electric motor 6 is determined to be turned off, ~~the processing proceeds to Step 42~~ is performed.

[0082] At Step 42, an initial control ~~revolution-number of~~ revolutions SR of the electric motor 6 is determined based on ~~the relationship with~~ based on the refrigerant pressure of the higher pressure portion shown in FIG. 4. The initial control ~~revolution-number of revolutions~~ SR is greater than the preset ~~revolution-number of revolutions~~ R.

[0083] At Step 43, electric current is applied to the electric motor 6 for driving the electric motor 6 at the initial control ~~revolution-number of revolutions~~ SR determined at Step 42.

[0084] At Step 44, it is determined whether the initial control ~~revolution-number of revolutions~~ SR is reached. When the initial

control ~~revolution-number~~ of revolutions SR is determined to be reached, ~~the processing proceeds to Step 45~~ is performed.

[0085] At Step 45, the control electric current S that is obtained from a state of the refrigerating ~~eyelecircuit~~ is applied to the capacity control valve 4a, as shown in FIG. 9. This ~~triggers-causes~~ the swash plate 41 to be rapidly inclined.

[0086] At Step 46, it is determined whether a preset time T1 ~~elapses~~ has elapsed. When the preset time T1 has elapsed, the ~~processing proceeds to Step 47~~ is performed.

[0087] At Step 47, the ~~revolution-number~~ of revolutions of the electric motor 6 is converged, at a preset time T2, to the preset ~~revolution-number~~ of revolutions R from the initial control ~~revolution-number~~ of revolutions SR.

[0088] At Step 48, the ~~revolution-number~~ of revolutions is controlled to remain at the preset ~~revolution-number~~ of revolutions R. Hereafter, when the electric motor 6 is determined to be ~~not turned-off~~ on at Step 41, ~~the processing proceeds to Step 48~~ is performed, where the revolution number is repeatedly controlled to remain at the preset ~~revolution-number~~ of revolutions R.

[0089] Features of this embodiment will be described. As explained in the first embodiment, in the swash-plate type externally variable displacement compressor of this embodiment, once the displacement starts ~~being recovered~~ to recover by virtue of inclination of the swash plate, force is apt to be applied for the displacement to increase. This tendency can be also utilized in this embodiment. The initial control ~~revolution-number~~ of revolutions SR is greater than the preset ~~revolution-number~~ of revolutions R. The initial control ~~revolution-number~~

of revolutions SR is used as a trigger for inclination of the swash plate. Since inertia of the swash plate is increased, the displacement of the compressor 4 can be rapidly recovered when the compressor 4 starts being driven by the electric motor 6.

[0090] Furthermore, the pressure sensor 26 is provided for detecting the refrigerant pressure in the higher pressure portion of the refrigerating ~~eyele-5~~circuit 5. According to the refrigerant pressure in the higher pressure portion of the circuit 5, the initial control ~~revolution-number~~ of revolutions SR is varied. The initial control ~~revolution-number~~ of revolutions SR is thereby set based on the cooling load of the refrigerating ~~eyele-5~~circuit 5.

[0091] After the compressor 4 starts being driven by the electric motor 6, the initial control ~~revolution-number~~ of revolutions SR continues to be used as a target only for the preset time T1. If the swash plate starts being inclined and the initial control ~~revolution-number~~ of revolutions SR still continues to be used at the target more than the preset time T1, excessive cooling or wasteful power consumption may also occur. The preset time T1 is suitable just for triggering inclination of the swash plate ~~to start being inclined~~.

[0092] As another aspect, the temperature sensor 29 is also provided for detecting the temperature of air (at the outlet of the evaporator 14) just after the air passes through the evaporator 14, as explained ~~in above~~ in the discussion of the first embodiment. After the compressor 4 starts being driven by the electric motor 6, a shifting point C at which the air temperature that has been increasing starts to decrease is detected in FIG. 9. By detecting the shifting point C, the

~~revolution-number~~ of revolutions can start to converge from the initial control ~~revolution-number~~ of revolutions SR to the preset ~~revolution-number~~ of revolutions R. This structure can also restrict ~~the~~-excessive cooling or wasteful power consumption.

[0093] The ~~revolution-number~~ of revolutions of the electric motor 6 converges from the initial control ~~revolution-number~~ of revolutions SR to the preset ~~revolution-number~~ of revolutions R at the preset time T2. This enables a gradual shift to usual control, so that worsening of cooling ~~feeling~~ or discomfort is prevented. Furthermore, providing the above control device in the compressor 4 enables ~~adopting~~ the use of a swash-plate type externally variable displacement compressor that rapidly recovers displacement when the compressor 4 starts being driven by the motor 6.

~~(Modification)~~

[0094] The first and second embodiments can be modified as explained below.

[0095] Although the initial control electric current SS and the initial control ~~revolution-number~~ of revolutions SR are varied based on the refrigerant pressure of the higher pressure portion, these initial control values can be constant values.

[0096] The electric current of the capacity control valve 4a converges from the initial control electric current SS to the control electric current S at the preset time T2. The ~~revolution-number~~ of revolutions of the electric motor 6 converges from the initial control ~~revolution-number~~ of revolutions SR to the preset ~~revolution-number~~ of revolutions R at the preset time T2. However, a gradual shift that needs the preset time T2 is not

always necessary. ~~Instance~~ An instant shift that does not need a certain period can be used instead of the gradual shift.

[0097] While the compressor 4 is driven by the motor 6, the ~~revolution-number~~ of revolutions of the electric motor 6 remains constant. However, the ~~revolution-number~~ of revolutions can be variable according to the cooling load. In the above hybrid compressor, the compression mechanism 4 and the electric motor 6 are integrally assembled. However, the compression mechanism can be a simple body. In this case, a rotation shaft of the compression mechanism is provided with an electromagnetic clutch and a pulley. The pulley is connected separately with an engine and an electric motor through belts, so that the compression mechanism is driven selectively by the engine or the electric motor.

[0098] The refrigerating ~~eyele~~ 5circuit 5 is for cooling the cabin of the vehicle. However, ~~it~~ the circuit can be for cooling a refrigerator or a freezer. In this case, cooling ~~for~~ of the refrigerator or the freezer can be continued during the loading/unloading work in the truck.

[0099] The present invention can be directed to a so-called hybrid vehicle that travels by a driving source of either an engine or an electric motor. It can be also directed to a vehicle having an engine dedicated for generating electricity. In this vehicle, an electric motor that is driven by the electricity generated by the engine is used for ~~driving source~~ of vehicle traveling moving the vehicle. Furthermore, the present invention can be directed to not only a vehicle but also a stationary refrigerating ~~eyeling~~ device driven by an engine.

[0100] It will be obvious to those skilled in the art that various changes may be made in the above-described embodiments of the present invention. However, the scope of the present invention should be determined by the following claims.

## ABSTRACT OF THE DISCLOSURE

When a hybrid compressor starts being driven by an electric motor, ~~an~~the electric current of a capacity control valve is applied at an initial control electric current SS that is greater than a control electric current S~~obtained~~, which is from a~~the~~ state of a refrigerating ~~eyelecircuit~~. This triggers a swash plate of the hybrid compressor to be rapidly inclined. Thereafter, the electric current of the displacement control valve is applied at the control electric current S. This structure enables thea displacement of the hybrid compressor to ~~be rapidly recovered~~rapidly recover when the hybrid compressor starts being driven by the electric motor.